MANAV RACHNA INTERNATIONAL INSTITUTE OF RESEARCH & STUDIES
(Deemed to be University under section 3 of the UGC Act 1956)

Ph.D ADMISSION TEST (MR-PAT)

Ph.D. in Mechanical Engineering

Module 1: Engineering Mathematics:

1.1 **Numerical Methods:** Numerical solutions of linear and non-linear algebraic equations; integration by trapezoidal and Simpson's rules; single and multi-step methods for differential equations.

1.2 **Differential Equations:** First order equations (linear and nonlinear); higher order linear differential equations with constant coefficients; Euler-Cauchy equation; initial and boundary value problems.

1.3 **Linear Algebra:** Matrix algebra, systems of linear equations, eigenvalues and eigenvectors.

Module 2: Fluid Mechanics and Thermal Sciences

2.1 **Fluid Mechanics:** Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.

2.2 **Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behavior of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.

2.3 **Heat-Transfer:** Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.

2.4 **Applications:** Power Engineering: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. I.C. Engines: Air-standard Otto, Diesel and dual cycles. Refrigeration and air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. Turbomachinery: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines; steam and gas turbines.

Module 3: Applied Mechanics and Design

3.1 **Engineering Mechanics:** Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

3.2 **Strength of Materials:** Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses;

strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

3.3 **Theory of Machines:** Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.

3.4 **Vibrations:** Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

3.5 **Machine Design:** Design for static and dynamic loading; failure theories; fatigue strength and the SN diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Module 4: Materials and Manufacturing

4.1 **Engineering Materials:** Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

4.2 **Casting, Forming and Joining Processes:** Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

4.3 **Machining and Machine Tool Operations:** Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, jigs and fixtures; abrasive machining processes; NC/CNC machines and CNC programming.

4.4 **Metrology and Inspection:** Limits, fits and tolerances; linear and angular measurements; Comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine (CMM).

Module 5: Industrial Engineering

5.1 **Computer Integrated Manufacturing:** Basic concepts of CAD/CAM and their integration tools; additive manufacturing.

5.2 **Production Planning and Control:** Forecasting models, aggregate production planning, scheduling, materials requirement planning; lean manufacturing.

5.3 **Inventory Control:** Deterministic models; safety stock inventory control systems.

5.4 **Operations Research:** Linear programming, simplex method, transportation, assignment, network flow models.

Suggested Readings:

1. Erwin kreyszig, 2006, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons.
2. S.K. Som and G. Biswas, "Introduction to Fluid Mechanics and Fluid Machines", Tata McGraw-HillsPublishing Company
3. Power Plant Engineering, by F.T. Morse, Affiliated East-West Press Pvt. Ltd.
4. V. Ganesan,2017, Internal Combustion Engines, 4th Edition, Tata McGraw-Hill.
5. A.H. Shapiro, 1953, Dynamics and Thermodynamics of Compressible fluid Flow, , John wiley, New York.
6. S.S. Rattan, " Theory of Machines", Tata McGraw Hill Publication
7. Theory and problems of Mechanical Vibrations: William. W. Seto, Schaum Outline Series, Mc Graw Hill Inc.
8. Mikell P. Groover, "Fundamentals of Modern Manufacturing: Materials, Processes, and Systems", Pearson Publication.
9. Pandey P.C. and Shan H.S. "Modern Machining Processes" Tata McGraw-Hill
10. S. L. Narasimhan, D. W. McLeavey, and P. J. Billington, Production, Planning and InventoryControl, Prentice Hall,1997.

Weblinks:

1. https://nptel.ac.in/courses/122104015
2. https://nptel.ac.in/courses/122104015
3. https://nptel.ac.in/courses/112103111/
4. http://nptel.ac.in/courses/112103174